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Energy Transfer to Upper Trophic Levels on a Small Offshore Bank

Lewis S. Incze
Aquatic Systems Group, University of Southern Maine
350 Commercial St., Portland, ME 04101
phone: (207) 228-1676 fax: (207) 228-1689 email: lincze@usm.maine.edu

David M. Fields
Bigelow Laboratory for Ocean Sciences
180 McKown Pt. Rd., West Boothbay Harbor, ME 04553
phone: (207) 563-3146 fax: (207) 563-9641 email: dfields@bigelow.org

Scott D. Kraus
New England Aquarium
Central Wharf, Boston, MA 02110
phone: (617) 973-5457 fax: (617) 973-0242 email: skraus@nea.org

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LONG-TERM GOALS

The primary goal of our research is to understand mechanisms that lead to highly focused feeding patterns of upper trophic level predators near offshore topographic features such as banks and ridges. These mechanisms likely differ from feature to feature and over time, but probably involve a limited number of key prey species, behaviors, and physical processes. Understanding the conditions and processes that generate feeding "hotspots" is essential to understanding their temporal variability, and whether good feeding conditions are limited by bottom-up or top-down controls (bottom-up would be characteristic of zooplankton prey, whereas top-down might prevail if schooling fish played a facilitating role and also were prey). The mechanisms and controls, in turn, influence the residence times and feeding success of mobile predators such as birds and marine mammals. The more ephemeral and less dependable the phenomena, the more frequent the movement of top predators must be in search of prey. This affects energy budgets (thus growth and reproduction) and average distributions of the top predators. Our second goal, tied to results of the first, is to understand factors that influence within and between-year differences in feeding conditions.

OBJECTIVES

This study is investigating the coupled physical-biological processes that lead to enhanced prey concentrations for feeding whales on Platts Bank, a small (<15 km long) submarine (55 m shallowest depth) glacial moraine in the western Gulf of Maine (ca. 43.2° N, 69.4° W). We are focusing on humpback whales (Megaptera noviangliae) and their eupahsuiid prey (Meganyctiphanes norvegica). Our evidence suggests that euphausiid swarms form briefly at the surface in response to the passage of internal waves. Our objectives are to (1) understand the small-scale flow environment around these waves (shears, current speeds, convergences); (2) the reaction of euphausiids (our focus) and other zooplankton (opportunistically) to these forces; and (3) the combination of conditions and reactions that give rise to surface swarms. Our hypothesis is that internal waves lead to euphausiid surface swarming over the bank when the waves are forced near the surface by an internal tide. Elsewhere, the waves may cause patchiness, but not at the surface. This only works when euphausiids are at the top of or above the pycnocline, which they were in our first year of observation (2005).

APPROACH

We are using a small research vessel (48') and anchoring at various places on the bank. We are using 75 kHz sound scattering to detect internal waves, euphausiids, and fish; a 1200 kHz ADCP to measure flows in the upper mixed layer (down to 15 m); and a camera system to examine zooplankton community composition, vertical distribution, and behavior related to internal waves. Two CTDs (one at constant depth and one in cast mode) record the vertical displacements of internal waves and pyncnocline thicknesses. Plankton nets are used to sample abundance of small zooplankton, such as copepods and euphausiid eggs and larvae. These samples also detect potential sound scatterers that are of lower mobility than euphausiids. In the laboratory, we will measure the neurological thresholds of eupahusiids to shear forces and compare these to shears in the environment. The field work is led by L. Incze, the camera and laboratory neurobehavior is led by D. Fields, and interpretation of data with respect to upper trophic level behavior and foraging models is led by S. Kraus. Andone Lavery (Woods Hole Oceanographic Institution) and James Lerzcak (Oregon State University) have generously assisted us with interpretation of acoustic and ADCP data, respectively, and we anticipate continuing these relationships.

WORK COMPLETED

In July and August 2007 we conducted 5 day-long (10-12 h) cruises, collecting approximately 100 CTD casts; > 25 h of continuous fixed-depth CTD and acoustic measurements; and a small number of net samples (most of the above have been analyzed). We (D. Fields) built and field-tested the camera apparatus with three different lighting set-ups: (1) natural light (used only for wide field of view above 20 m); (2) bright halogen bulbs to attract local organisms; and (3) IR light to view (but not attract) organism at depth. A velocimeter mounted in front of the camera system measured the 3D velocity structure of the water column at scales relevant to the sensory perception of small rheotactic animals.

RESULTS

Our hydrographic work confirmed an earlier (but insufficiently long) data set indicating that there is an internal tide on the bank that brings the average depth of the pycnocline and the internal wave field closer to the surface (by up to 10 m). This occurs during periods of strong tidal flows. The largest waves (amplitudes of 10 or more m) come very close to the sea surface. We also confirmed that internal waves are present >80% of the time (data are not yet completely analyzed) and form a complex set of wave frequencies and amplitudes (classic, isolated wave packets were rarely seen). This suggests waves are coming from multiple sources.

In 2007 there were no surface swarms of euphausiids; no dense populations were detected with acoustics; none were seen with the camera; no euphausiid eggs or larvae were sampled as in previous years. The population was clearly very low during this period, and there was little marine mammal presence on the bank. This was an important observation in terms of interannual variations, though it didn't permit any behavioral observations on this species.

ADCP data have not yet been analyzed. The temperature and velocity measurements on the camera system showed changes in small-scale velocity with the passage of internal waves. Difficulties have been the low particle counts in the water column causing low signal to noise ratios in our acoustic data. In addition, the camera apparatus, mounted from the boat, is experiencing significant water motion in both the video data and the acoustic data. We are presently discussing a possible spar mounting system that would make surface deployment easy and still dampen the surface wave motion.

IMPACT/APPLICATIONS

Too early in the project (field work began in late July 2007)

RELATED PROJECTS

The Navy's interest in the distribution and movement of whales overlaps with the same interests of the Census of Marine Life program (processes influencing patterns of biodiversity in the oceans) and with NOAA agency interests in the conservation of marine mammal populations. This project is a collaboration with the Census of Marine Life, Gulf of Maine Area Program, and is sharing results with the Marine Mammal Division of the Northeast Fisheries Science Center (Woods Hole) and the marine mammal investigations of the Stellwagen Bank National Marine Sanctuary (conducted by the sanctuary and by investigators at WHOI).